Green Lake Water Quality

Monitoring Results
for Water Year 2010 at Green Lake

Green Lake *Photo by Sally Abella*

Prepared for the City of Seattle
by the King County Lake Stewardship Program

March 31, 2011

King County

Overview

The King County Lake Stewardship Program (KCLSP) has worked with volunteer monitors on Green Lake since 2005 to track water quality, which has been of particular interest after the alum treatment of the lake was carried out in 2004 to control phosphorus concentrations in the water column. The volunteers undergo training and use equipment owned and maintained by King County. An example of the volunteer training manual is available on-line at
http://www.kingcounty.gov/environment/waterandland/lakes/documents/manual.aspx

Two sampling stations in the lake were established in 2005 and measurements were taken at both sites in the years 2005 – 2008. Beginning in 2009, only one station was monitored for water quality, while some of the year-round physical monitoring occurred from the dock at East Green Lake (Figure 1).

Figure 1. **Station locations**

Green Lake is surrounded by a public park, and car-top boats can be launched at various points around the lake. It has a history of milfoil infestation, for which eradication efforts have been undertaken from time to time. Green Lake has also been closed to recreation for bluegreen algae blooms several times and has been treated for nutrient reduction to control algae, including all-lake alum treatments in 1991 and again in 2004.

The most recent treatment had a significant impact on nutrients and immediately improved the water quality of the lake. The 2010 data indicate that this lake is currently low to moderate in primary productivity (lower mesotrophic) with good water quality. Information from the current monitoring project will be used to assess the longevity of the alum treatment's effect.

This report refers to two common measures used to predict water quality in lakes: the Trophic State Index or TSI (Carlson 1977), and the nitrogen to phosphorus ratio (N:P). The TSI and N:P ratios are calculated from the data collected through the volunteer monitoring program. TSI values are derived by a correlation that relates measured values of several parameters such as total phosphorus, chlorophyll *a* and Secchi transparency to estimated algal biovolume, rescaling the result to a range of 0 to 100. These numbers can be used to compare water quality over time and between lakes. Not enough data has been collected to date at Green Lake to verify an apparent trend statistically, but it appears that the lake is currently stable or even slightly decreasing in productivity over the short term.

The discussion in this report focuses on the 2010 water year, which runs from October 2009 through September 2010 with the addition of two water quality sample dates in October 2010, and compares it to past years through the TSI indicators. Specific data used to generate the charts in this report can be downloaded from the King County Lake Stewardship data website at:

http://www.metrokc.gov/dnrp/wlr/water-resources/small-lakes/data/default.aspx.

Or can be provided in the form of excel files upon request.

Physical Parameters

Excellent precipitation and water level records were compiled for the 2010 water year. There is a small amount of variation in lake water level through the year, which does not always match the precipitation record (Figure 2). There was one sudden drop in lake level in late October, which could be related to management activities by the Seattle Parks Department or Seattle Public Utilities, agencies that are joined in responsibility for lake management.

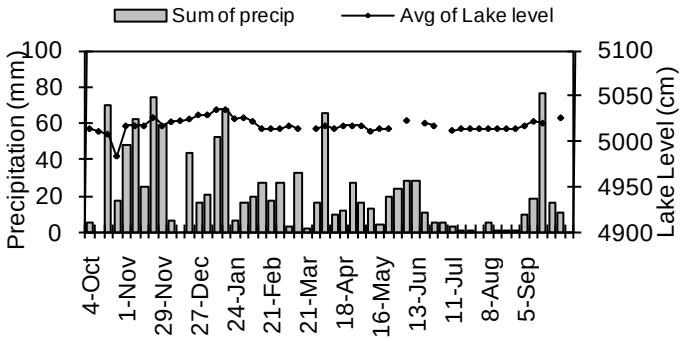

Figure 2: Green Lake Water Level and Precipitation WY 2010

The students from Billings Middle School under supervision of their teachers collected physical data from the dock at East Green Lake throughout the year (see Figure 1). Volunteer monitors collected Secchi transparency and temperature data from early May through late October at lake station Green-1 (over the deepest part of the lake) as part of the water sample collection routine.

Secchi transparencies at Green-1 ranged between 1.9 and 4.9 m from May through October, averaging 3.6 m (Figure 3), while student measurements made throughout the year from the dock ranged between 1.4 and 4.4 m, averaging 3.0 m over the entire year and 3.3 between May - October. There was fairly good agreement between the volunteer reading at the sampling site and the student readings at the dock, taking into account the many different factors that can bias a Secchi measurement, such as windiness , different vision, glare, and location on the lake. In addition, the shallow water column at the dock site limited the depth to which the Secchi disk could be lowered, and the depth may recorded sometimes may have been based on water depth rather than disappearance of the Secchi from view, which can bias the average towards a lower value, which appeared to have happened in 2009. However, the wide variability of the students' Secchi measurement throughout the year at the dock suggests this may not have been a big factor in 2010.

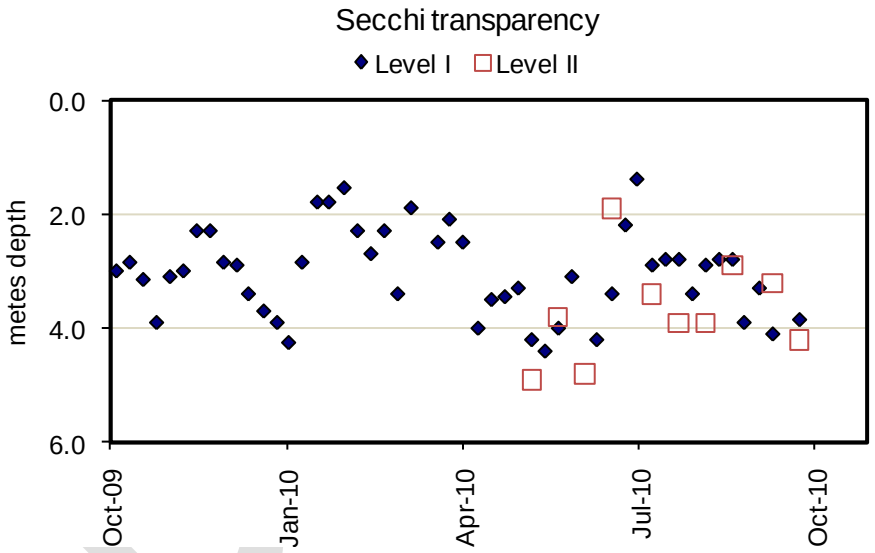

Figure 3. WY 2010 Green-1 and East Dock Secchi transparency

At station Green-1 surface water temperatures from May through October ranged between 12 and 22.5 degrees Celsius with an average temperature of 19.0 (Figure 4). At the East Dock, temperatures ranged from 5.0 to 23.0 degrees Celsius with an average of 14.0 over the entire year and a May – October average of 17.8. Green Lake is in the lower third for summer maxima recorded among the lakes monitored in 2010.

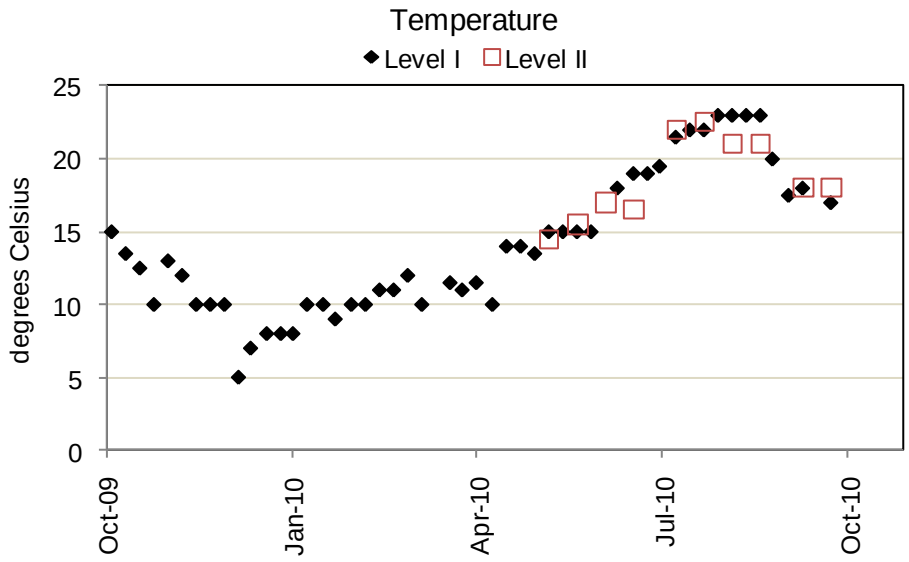

Figure 4. WY 2010 Green-1 and East Dock Temperatures

Nutrient and Chlorophyll Analysis

Phosphorus and nitrogen are naturally occurring elements necessary in small amounts for both plants and animals. However, many actions associated with residential development can increase concentrations of these nutrients beyond natural levels. In lakes of the Puget Sound lowlands, phosphorus is most often the nutrient in least supply relative to the biological demand; this means that biological productivity is often limited by the amount of phosphorus available for growth and reproduction. Increases in phosphorus concentrations can lead to more frequent and dense algae blooms – a nuisance to residents and lake users, and a potential safety threat if blooms become dominated by species that can produce toxins.

The alum treatment in 2004 at Green Lake reduced the amount of phosphorus available by binding it tightly, thus keeping it from being taken up by growing algae. Since 2005, water quality samples collected by volunteers between May and October have been analyzed for total phosphorus (TP) and total nitrogen (TN) concentrations at one meter depth, with deeper water also sampled twice during the period each year.

At Green Lake-1 neither TN nor TP varied greatly, remaining fairly consistent through the sampling period (Figure 5). Please note that the units for TN are 10 times higher than for TP on the chart, so when values for the two parameters are close together on the graph, nitrogen is 10 times more abundant by weight.

The ratio of nitrogen (N) to phosphorus (P) can be used to determine if conditions are favorable for the growth of cyanobacteria (bluegreen algae) that can impact beneficial uses of the lake. When N:P ratios are routinely below 20, cyanobacteria often dominate the algal community due to their ability to take nitrogen directly from the air. From May – October total phosphorus and total nitrogen ratios ranged from 12.6 to 24.2 with an average of 19.3, with five dates having an N:P ratio above 20, although 3 of these were very close. This suggests that the summer conditions may have been favorable frequently

for nuisance bluegreen growth in the lake, although the low concentration of available phosphorus overall may have kept significant blooms from forming.

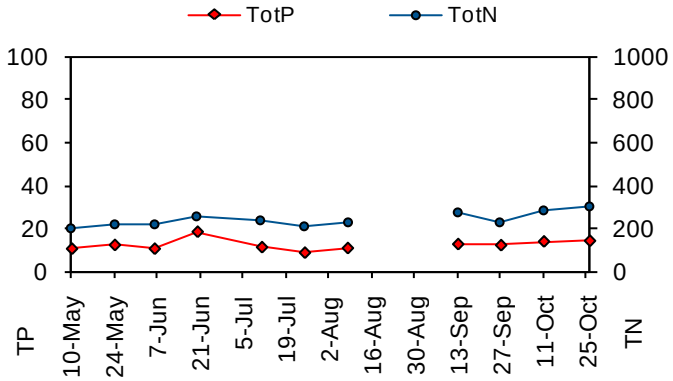

Figure 5. 2010 Green-1 Total Phosphorus and Total Nitrogen Concentrations

Chlorophyll *a* remained at relatively low values with small variations through the entire sampling period at Green-1, consistent with low phosphorus availability. Pheophytin (degraded chlorophyll) was also low throughout the sampling season, though on one date in early July, it was essentially equivalent to Chlorophyll a (Figure 6). The shallow nature of the lake coupled with a relatively large fetch probably leads to some sediment resuspension and recirculation of degraded chlorophyll from the sediments to the water column.

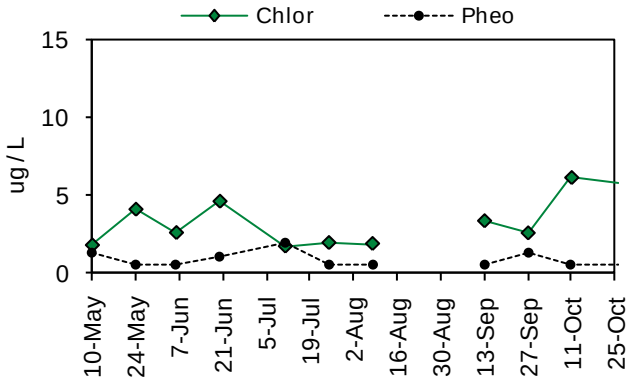

Figure 6. 2010 Green-1 Chlorophyll *a* and Pheophytin concentrations

The King County swimming beach program included weekly samples for the bluegreen algal toxin microcystin as well as fecal coliform bacteria concentration, from late May through September in 2010. All toxin results were below the minimum detection level, which can be viewed at: http://green.kingcounty.gov/swimbeach/.

Profile data (Table 1) from Green-1 indicate that the lake was fairly well mixed thermally throughout the sampling season. No increases in ammonia were found in the deep water on either date, which is an indicator that anoxia was unlikely to have developed in the deep water through the summer. The lack of temperature differences between shallow

and deep water also lends support to the idea that thermocline development was most likely transitory, as it generally has been in the past in Green Lake.

Concentrations of phosphorus in the deep water remained equivalent to shallow depths, showing that any small amount of phosphorus released from the sediments under oxygenated conditions was likely mixed through the entire water column. Chlorophyll a data indicated that algae were equally distributed through the water column and remained low in concentration over all.

Table 1. Green-1 Profile Sample Analysis Results

Lake name	Date	Secchi	Depth	DegC	Chlor-a	Pheo	Total N	NH3	Total P	OPO4	UV254	Total Alk
Green	5/24/10	1.0	1	15.5	4.1	<MDL	0.220	<MDL	0.0123	<MDL	0.015	36.8
			3	15.0	3.8	<MDL	0.277		0.0218			
			6	15.0	4.0	<MDL	0.226	<MDL	0.0116	<MDL		
Green	8/23/10	2.9	1	21.0	4.3	<MDL	0.281	0.016	0.0223	0.0021	0.070	39.8
			3	21.0	2.2	1.3	0.233		0.0157			
			6				0.240	0.014	0.0160	<MDL		

NOTE: In Table 1, <MDL stands for "below minimum detection level" of the analytical method.

The low values for UV254 indicate that the water of the lake is not colored by organic substances, while the total alkalinity values show that the water in the lake is relatively soft, in the mid range for lakes that have been measured in King County, and only lightly buffered from pH change.

TSI Ratings

A common method of tracking water quality trends in lakes is by calculating the "trophic state index" (TSI), developed by Robert Carlson in 1977. TSI indicators predict the biological productivity of the lake based on water clarity (Secchi) and concentrations of TP and chlorophyll *a*.

At station Green-1 in 2010 the TSI-Chlorophyll indicator was in the lower range of mesotrophy, approximately equivalent to the value for TSI-TP, but lower than the value for TSI-Secchi (Figure 7). These values have varied from year to year since the alum treatment in 2004, but have shown no trend towards increase in algae productivity thus far and have remained consistently near the boundary between oligotrophy and mesotrophy (TSI value of 40). Values used for calculating the TSI values for the years 1995 – 2004 were provided by Kevin Stoops of the Seattle Parks Department and Rob Zisette of Herrera Environmental. It should be noted that while 1995 – 1996 were sampled throughout the summer, values for 2000 were based on 3 sample dates only from May through July of that year.

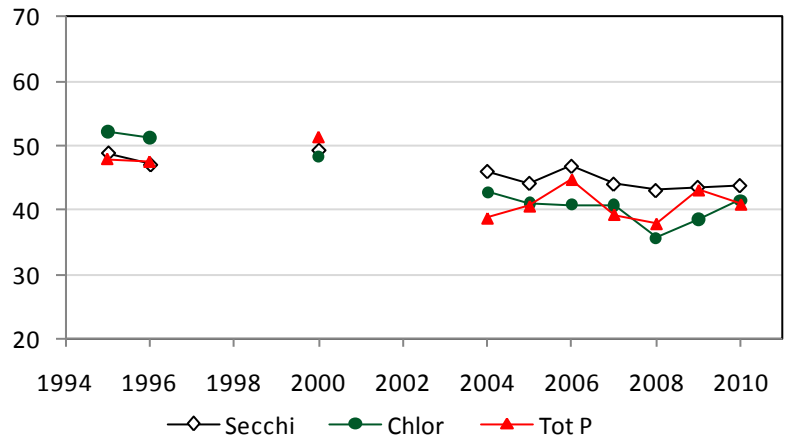

Figure 7. Green Lake-1 Trophic State Indicators

In addition to the volunteer monitoring conducted described in this report, the following additional monitoring data were collected at Green Lake during WY 2010 by other agencies and programs:

- King County Swimming Beach Monitoring (http://green.kingcounty.gov/swimbeach/)
- SPU continuous stage measurements (available from Seattle Public Utilities upon request)
- Water quality monitoring by Seattle Parks department (available upon request)

Conclusions and Recommendations

Based on monitoring data, water quality in Green Lake has been relatively stable over the period measured since the alum treatment in 2004. The low N:P ratios could indicate conditions are often favorable for bluegreen algae growth, but overall low levels of available phosphorus have likely kept major blooms from forming. Continued monitoring of nutrient and chlorophyll concentrations should be continued to assess conditions and to verify trends, in particular to document the longevity of the effect of the 2005 alum treatment.

Algae accumulations at the lake that occur at places and times other than the monitored swimming beaches during summer should also be sampled, including submitting bloom or scum samples to the Washington State Department of Ecology's Toxic Algae Monitoring Program to determine whether or not blooms at the lake are producing toxins.